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THE EFFECT OF PROPPING LIQUID ON THE GLASS CUTTING PROCESS

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The effect of various propping liquids on the glass cutting process is analyzed: on the wear of the roll cutter edge, the force of breaking glass along the inflicted cutting line, and on the load applied to the roll cutter. The results of studying the effect of propping liquids on chip formation and their washability off the glass surface are considered.

The easiest and the most common method for glass cutting consists in using a hard-alloy roll cutter. For appropriate cutting of glass and obtaining a high-quality glass edge, one should adhere to certain (optimum) cutting parameters [1]. Among the basic parameters is the use of propping liquid, which is a unique vehicle for controlling the cutting process, the quality of the edge and the end face of the glass article, as well as reliability and durability of the cutting instrument.

The propping liquid should meet a number of requirements:

- be inactive (nonpolar material) with respect to glass;
- decrease the glass-breaking force along the cutting line;
- reduce chip formation (lateral cracking at the glass edge);
- delay the wear of the roll and the roll-holder shaft;
- not cause corrosion of the cutting instrument
- ensure the facility of the roll gyration;
- be environmentally safe;

At present glasses with various coatings are produced, and enhanced requirements are imposed on the quality of the glass surface, including the requirement that no traces of the propping liquid be seen on the glass. The Saratov Institute of Glass performs metallization of glass produced on the ÉPKS-4000 line, and the propping liquid used in cutting the moving glass band is kerosene, which is traditionally used in the domestic production. Kerosene is hard to wash off the glass surface and furthermore, does not have a lubricating effect. Therefore, to lubricate the cutting tools, various technical oils are often added to kerosene, which produces traces along the glass sheet edge that are even harder to wash off. Therefore, in the final cutting of glass sheets, the edges have to be cut off as waste, which raises the cost of the finished product. In addition to the above disadvantages, kerosene is toxic and very inflammable.

The purpose of the present paper is to study the effect of various propping liquids on the cutting quality and their capacity for being washed off the glass surface.

Several propping liquids have been studied earlier at the Saratov Institute of Glass [2]. The efficiency of the considered liquids was evaluated based on the force of breaking a glass sample along the cutting line. It can be seen from Fig. 1 that aqueous solutions of such surfactants as OP-7, sodium nitrite, and carboxymethyl cellulose decrease the breaking force by 20–30 % compared to kerosene only when the cutting load is up to 70 N. The most effective, 2.5% aqueous solution of syntamide, is effective under all loads and significantly decreases the breaking force from 4 MPa to 0, as the load grows from 70 to 100 N, in other words, it develops the conditions for the formation of a through crack. The polyethyl siloxane liquid ПЭС-4 (GOST 13004–67) belonging to the class of organosilicon compounds and having high chemical affinity to glass ensures a decrease in the breaking force and better quality of cutting and edge, compared to kerosene, when roll cutters are used with various sharpening angles under almost any load, especially under optimum loads. For instance, the breaking force under a load of 100–110 N decreases by 20–25%.

The effect of propping liquids on the wear of the roll cutter edge along the curvature radius of its sharpening angle, which grows as the roll becomes dull, has been investigated. It has been established that syntamide solution significantly shortens and ПЭС-4 liquid significantly extends the service life of the roll cutter. Furthermore, ПЭС-4 liquid does not cause the corrosion of metal parts and is environmentally safe (USSR Inventor's Certif. No. 631465).

It follows from Fig. 1 that the optimum load applied to the cutting roll when cutting glass with a propping liquid is lower than when cutting without liquid. A decreased load ap-

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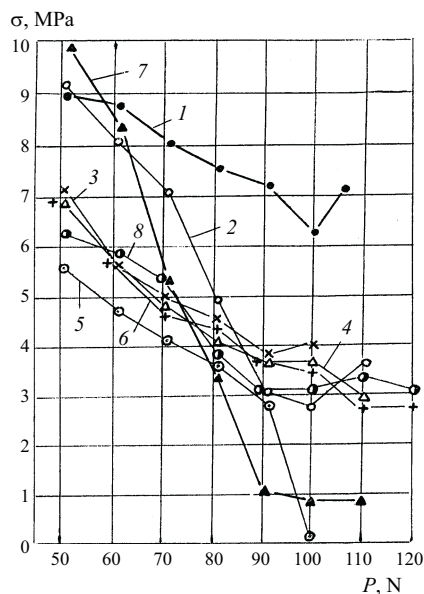


Fig. 1. Breaking force σ versus load applied to the roll P : 1) without propping liquid; 2) with kerosene as propping liquid; 3) with water; 4) with 0.25% aqueous solution of carboxymethyl cellulose; 5) 2.5% solution of syntamide; 6) 1% aqueous solution of sodium nitride; 7) PÉS-4; 8) 0.3% aqueous solution of OP-7.

plied to the cutting roll extends its service life, improves the glass edge quality, and improves labor conditions in manual cutting of glass.

However, the effect of the propping liquid on chip formation and on the washability of the glass surface was not investigated.

It is known that cutting glass leads to the formation of chips (as a consequence of lateral cracks reaching the surface), which can lower the glass surface quality. One of the functions of the propping liquid is to decrease chip formation. Accordingly, we investigated the effect of specific propping liquids on chip formation: kerosene, kerosene mixed with 20% machine oil, PÉS-4, and water. The chip formation parameters were as follows:

- the number of fragments (chips) per cm^2 of glass surface area produced by inflicting a cutting line;
- the width of the fragmented band along the cutting line inflicted on the glass surface.

The cutting lines were inflicted on the surface of float glass samples 500×300 mm using a hard-alloy roll cutter with a sharpening angle of 140° and a load of 100 N applied to the roll along the cutting line, both with and without propping liquid. After inflicting the cutting line, the width of the fragmented band was measured employing a MBS-1 microscope, the number of fragments was counted, and their quantity per cm^2 of the band was determined. The obtained results are seen in Table 1.

It can be seen that the minimum number of fragments and the minimum width of the fragmented band are registered in cutting glass using PÉS-4 propping liquid.

TABLE 1

Propping liquid	Chip formation parameters	
	number of fragments per cm^2 of glass band	width of fragmented band, mm
PÉS-4	0.2	0.25
Kerosene mixed with 20% machine oil	2.0	0.30
Kerosene	4.0	0.70
Water	5.0	0.50
No lubrication	9.0	1.00

TABLE 2

Propping liquid	Number of fragments per cm^2 of glass band at glass temperature			
	20°C		80°C	
	after 1 min	after 3 min 40 sec	after 1 min	after 3 min 40 sec
PÉS-4	0.2	0.2	0.2	0.2
Kerosene mixed with 20% machine oil	2	2	3	4
Kerosene	4	5	5	7
Water	5	6	7	8
No lubrication	9	10	11	14

The practice shows that chips can be formed not only at the moment of inflicting the cutting line, but for a certain time after that as well. The dependence of chip formation on the time passing since the moment of inflicting the cutting line on the glass surface was studied. The studies were performed in the laboratory conditions (in accordance with the above described method) with the glass surface temperature equal to 20°C , and directly on the float-glass production line (ÉPKS-4000 line) as well, and the temperature of the glass surface at the moment of inflicting the cutting line equal to 80°C . The minimum time (1 min) was taken as the time needed to count the number of fragments along a cutting line 500 mm long, and the maximum time (3 min 40 sec) was the time in which 5-mm glass is transported from the edge cutters (inflicting the cutting line) to the edge breakers (fracture along the cutting line). The obtained results are given in Table 2.

It can be seen that the number of fragments remains constant as the time passing since the moment of inflicting the cutting line increases from 1 min to 3 min 40 sec, in the cases of cutting glass using PÉS-4 (at both temperatures 20°C and 80°C) or kerosene mixed with oil at temperature 20°C , whereas in all other cases the number of fragments grows.

As the glass temperature changes from 20°C to 80°C , the number of fragments per 1 cm^2 of the band grows in all cases, except when using PÉS-4 liquid.

Thus, based on the specified parameter (chip formation), one can infer the advantages of PÉS-4 liquid and kerosene mixed with machine oil.

The washability of kerosene, kerosene mixed with 20% machine oil, and PÉS-4 liquid off the glass surface was studied well. The washing liquids were water, 2% ammonium hydroxide, and ethyl alcohol, in accordance with the Technological Regulations for Metallized Glass Production.

A drop (30 mg) of propping liquid was deposited with a syringe on the surface of two glass samples of size 50×50 mm. The surface of one sample was wiped with a cotton cloth (100×100 mm) moistened in 50 g of washing liquid, and the surface of the second sample was wiped with a dry cloth. The samples were wiped twice with a pressure applied to the glass equal to 2×10^4 Pa (0.2 kgf/cm²). After wiping, the presence and the thickness of the film remaining on the glass surface was determined and compared to the surface of a clean sample.

The state of the sample surface was studied using IR spectroscopy in the reflection mode on a Specord M 80 spectrophotometer and ellipsometry on a LÉM-2 laser ellipsometer. An analysis of the reflection spectra in the IR range of glasses with deposited films revealed that at 1200 cm^{-1} the peak intensity corresponding to the valence vibration of the Si – O bond in SiO₂ is lower than in the clean glass, which is related to the screening effect. The reflection spectra of the samples after dry wiping had slightly different parameters from the clean glass parameters, which is evidence of the

presence of a thin (10 – 20 Å) film on their surfaces. After the moist wiping, the reflection spectra of the clean sample and the investigated samples virtually coincided, which points to the absence or a very small thickness of the remaining film. No significant difference was registered in the thickness of the films produced by various propping liquids.

Thus, the most suitable of the tested liquids is PÉS-4.

The Saratov Institute of Glass continues research on propping liquids: the scientists are searching for a liquid easily washed with water, which would have good anticorrosion properties with respect to the roll and good propping properties. A liquid has been identified that leaves a significantly more narrow trace on the glass surface than kerosene does in cutting the moving glass band, and the properties of this liquid are currently being investigated. The use of this liquid along with its other advantages will make it possible to lower the production cost of coated glasses.

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